12.0 ALL CANCERS

STATEMENT TO THE PUBLIC

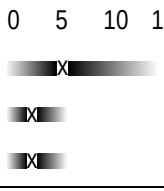
EMFs as a general cancer risk

The reviewers used two distinct sets of guidelines to evaluate the evidence:

Using the traditional guidelines of the International Agency for Research on Cancer, they considered the evidence as "inadequate" to implicate EMFs.

- *Using the Guidelines developed especially for the California EMF Program, they concluded that they "strongly believe that exposure to EMFs at home or work do not add" to an individual lifetime risk of contracting cancers of any kind, other than those specifically in this document.*

CONDITION	REVIE-WER	IARC CLASS	CERTAINTY PHRASE	DEGREE OF CERTAINTY IN CAUSALITY FOR POLICY ANALYSIS
Do EMFs increase the risk of all cancers?	1	3	Strongly believe not	0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
	2	3	Strongly believe not	
	3	3	Strongly believe not	



12.1 EVIDENTIARY BASE

Several studies on utility workers (Miller et al., 1996) have reported a number of associations with cancers other than those for which a clear hypothetical risk has been established (leukemia, CNS/brain, breast). However, only one study (Floderus et al., 1999) looked systematically at incidence rates for all cancer sites. The study explored the correlation between cancer incidence and exposure in occupations reported in census forms, assessed using a job exposure matrix.

The strengths of this study include:

- Large numbers (1,596,959 men and 806,278 women)
- Good data bases

The main weaknesses are:

- Registry, census-based study
- Coarse job-matrix exposure assessment (low, medium, high)

Summary of results:

- No dose-response relationship
- About 10% increase in risk in medium- and high-exposure groups
- Clear differences between results for men and women

Notable associations found in men:

- Colon
- Biliary passages and liver
- Larynx and lung
- Testis and kidney
- Urinary organs
- Malignant melanoma
- Non-melanoma skin cancer
- Astrocytoma III-IV

Notable associations found in women:

- Lung
- Breast
- Corpus uteri
- Malignant melanoma
- Chronic lymphocytic leukemia

The authors suggest that their results point to a possible interaction with the endocrine/immune system.

12.1.1 SUMMARY OF THE EVIDENCE

Figure 12.1.1

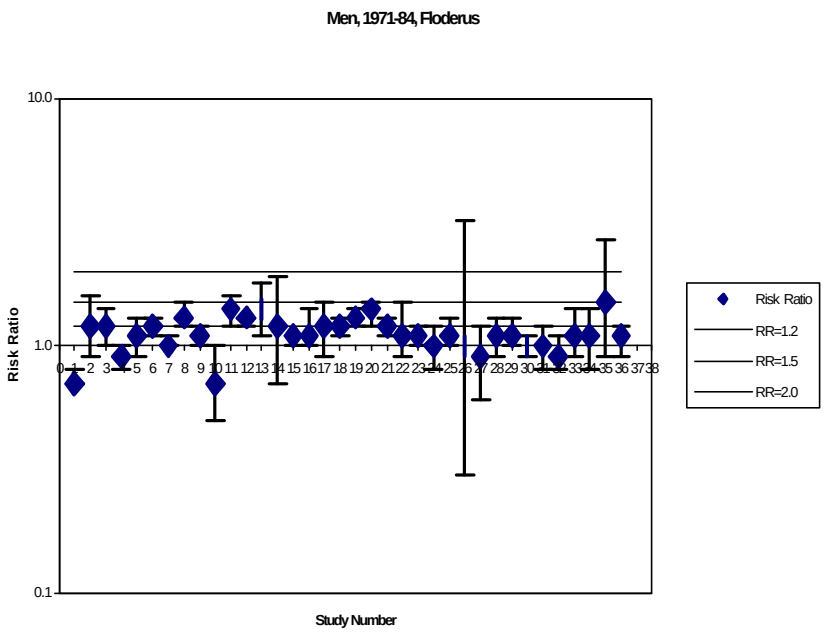


TABLE 12.1.1 MEN 1971-84

CANCER TYPE	STUDY NUMBER	N	INDIV. RISK RATIO, MEAN	LOWER CL	UPPER CL
Buccal cavity	1	253	0.7	0.7	0.8
Pharynx	2	91	1.2	0.9	1.6
Esophagus	3	315	1.2	1.0	1.4
Stomach	4	1,393	0.9	0.8	1.0
Small intestine	5	147	1.1	0.9	1.3
Colon	6	1,774	1.2	1.1	1.3
Rectum	7	1,360	1.0	1.0	1.1
Biliary passage & liver	8	588	1.3	1.2	1.5
Pancreas	9	941	1.1	1.0	1.2
Nose & nasal sinuses	10	71	0.7	0.5	1.0
Larynx	11	421	1.4	1.2	1.6
Lung, primary	12	2,999	1.3	1.2	1.3
Lung, other	13	129	1.4	1.1	1.8
Breast	14	37	1.2	0.7	1.9
Prostate	15	3,409	1.1	1.0	1.1
Testes	16	303	1.1	1.0	1.4
Other male genital organs	17	150	1.2	0.9	1.5
Kidney	18	1,343	1.2	1.1	1.3
Urinary organs excl. kidney	19	1,791	1.3	1.2	1.4
Malignant melanoma, skin	20	1,097	1.4	1.2	1.5
Non-melanoma skin cancer	21	1,240	1.2	1.1	1.3
Eye	22	104	1.1	0.9	1.5
Nervous system	23	1,100	1.1	1.0	1.2
Thyroid gland	24	200	1.0	0.8	1.2
Other endocrine glands	25	437	1.1	1.0	1.3
Phaeochromocytoma	26	5	1.0	0.3	3.2
Bone	27	80	0.9	0.6	1.2
Connective tissue, muscle	28	228	1.1	0.9	1.3
Connective tissue, other/unspec.	29	694	1.1	1.0	1.3
Malignant non-Hodgkin's lymphoma	30	776	1.0	0.9	1.1
Hodgkin's disease	31	257	1.0	0.8	1.2
Multiple myeloma, plasmocytoma	32	391	0.9	0.8	1.1
Acute myeloid leukemia	33	199	1.1	0.9	1.4
Chronic myeloid leukemia	34	116	1.1	0.8	1.4
Acute lymphoblastic leukemia	35	32	1.5	0.9	2.7
Chronic lymphocytic leukemia	36	301	1.1	0.9	1.2

Figure 12.1.2

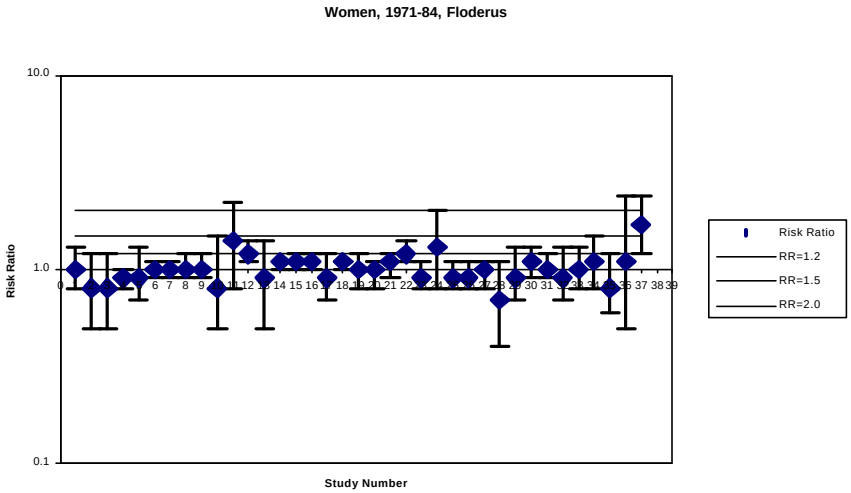


TABLE 12.1.2 WOMEN 1971-84

CANCER TYPE	STUDY NUMBER	N	INDIV. RISK RATIO, MEAN	LOWER CL	UPPER CL
Buccal cavity	1	128	1.0	0.8	1.3
Pharynx	2	36	0.8	0.5	1.2
Esophagus	3	40	0.8	0.5	1.2
Stomach	4	442	0.9	0.8	1.0
Small intestine	5	64	0.9	0.7	1.3
Colon	6	1,018	1.0	0.9	1.1
Rectum	7	603	1.0	0.9	1.1
Biliary passage & liver, primary	8	398	1.0	0.9	1.2
Pancreas	9	394	1.0	0.9	1.2
Nose & nasal sinuses	10	21	0.8	0.5	1.5
Larynx	11	37	1.4	0.8	2.2
Lung, primary	12	646	1.2	1.1	1.4
Lung, other	13	32	0.9	0.5	1.4
Breast	14	4,886	1.1	1.0	1.1
Cervix uteri	15	909	1.1	1.0	1.2
Corpus uteri	16	1,368	1.1	1.0	1.2
Uterus, part unspecified	17	130	0.9	0.7	1.2
Ovary, tube & broad ligament	18	1,479	1.1	1.0	1.1
Other female genital	19	188	1.0	0.8	1.2
Kidney	20	4,161	1.0	0.8	1.1
Urinary organs excl. kidney	21	306	1.1	0.9	1.2
Malignant melanoma, skin	22	657	1.2	1.1	1.4
Non-melanoma skin cancer	23	481	0.9	0.8	1.1
Eye	24	47	1.3	0.8	2.0
Nervous system	25	598	0.9	0.8	1.1
Thyroid	26	275	0.9	0.8	1.1
Other endocrine glands	27	457	1.0	0.8	1.1
Bone	28	28	0.7	0.4	1.1
Connective tissue, muscle	29	98	0.9	0.7	1.3
Connective tissue, other & unspec.	30	412	1.1	0.9	1.3
Malignant non-Hodgkin's lymphoma	31	297	1.0	0.9	1.2

CANCER TYPE	STUDY NUMBER	N	INDIV. RISK RATIO, MEAN	LOWER CL	UPPER CL
Hodgkin's disease	32	72	0.9	0.7	1.3
Multiple myeloma, plasmocytoma	33	187	1.0	0.8	1.3
Acute myeloid leukemia	34	107	1.1	0.8	1.5
Chronic myeloid leukemia	35	57	0.8	0.6	1.2
Acute lymphoblastic leukemia	36	12	1.1	0.5	2.4
Chronic lymphocytic leukemia	37	87	1.7	1.2	2.4

1 For this evaluation the reviewers will exclude from the above data all information
2 relating to the cancers individually evaluated elsewhere in this document

12.2 ARGUMENTS FOR AND AGAINST CAUSALITY

TABLE 12.2.1

CHANCE		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
(A1) Most of the results are not statistically significant.	(F1) The commonly chosen 95% level of significance is a safeguard against false positives, but may result in many false negatives if not accompanied by an equally high statistical power. Many elevated ORs argue at least for further investigation	(C1) The database is very limited and chance cannot be excluded as an explanation, but cannot be confidently assumed as THE obvious explanation. Some results are suggestive of an association; some are statistically significant and deserve more attention. On the whole, it may be said that "something seems to be going on here," but the evidence is not statistically stable enough to affect the reviewers prior.

TABLE 12.2.2

BIAS		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
(A1) This is a registry-based study, where many biases may have crept in.	(F1) Biases can affect the risk estimates in either direction.	(C1) There is no reason to believe that biases are more likely to be responsible for an association, rather than diminishing or masking one.

TABLE 12.2.3

CONFOUNDING		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
See argument for bias.	See argument for bias.	See discussion for bias.

TABLE 12.2.4

STRENGTH OF ASSOCIATION		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
(A1) Most of the positive associations are not strong, which decreases confidence that they are not due to artifacts.	(F1) If the effect is intrinsically weak, the association is correspondingly weak. This cannot be construed against causality.	(C1) If the association is intrinsically weak, low ORs cannot be construed as an argument against causality. While a strong relative risk would increase confidence in the hypothesis, there is no reason why the opposite should decrease it.
	(F2) The inevitably poor exposure assessment in occupational studies is very likely to result in a strong bias toward the null.	
	(F3) Some associations are quite strong.	
	(F4) Most hazardous agents at ambient doses do not produce strong risks.	

TABLE 12.2.5

CONSISTENCY		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
(A1) There is no consistency in the pattern of results.	(F1) It is true that the pattern of results for women is inconsistent and compatible with the null hypothesis.	(C1) There appears to be a clear difference between the results for the two genders. There really is no evidence to support the hypothesis that EMF exposure is a broadband risk factor for all cancer in women. However, the pattern of results for men is quite different and suggestive of a risk for a number of cancers.
	(F2) The pattern of results for men is quite different. The number of risk estimates above 1 is far greater than what would be expected by chance ($p = 0.003$)	

TABLE 12.2.6

COHERENCE		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
(A1) The results for women and men are clearly heterogeneous. The heterogeneity of the results along gender lines, unless supported by a biological explanation, argues against causality.	(F1) The results are homogeneous when stratified by gender. The results for men are very clearly distributed about an OR of 1.15 (on a log scale), with 50% of the studies being in an interval between 1 and 1.2.	(C1) The results for women are clearly consistent with no effect. Although the results for men are more consistently elevated, they do not appear to be randomly distributed about a clear maximum-likelihood value. The mode is about 1, but there is a clear tail of elevated risks, without a corresponding tail of ORs lower than 1. Since the results refer to different clinical endpoints, this asymmetry should not be seen as inconsistent with a true effect. Although a clear pattern is not seen, the authors of the study suggest that cancers of the reproductive system and other hormone-mediated cancers are more clearly associated with EMF exposure. This, or similar theories, may explain the skewed distribution of the results.
	(F2) This is a study on multiple endpoints. There is no reason to expect homogenous results.	(C2) Since this evaluation is based on a single study, there is no way to determine whether the internal discrepancies are more likely to be due artifact or reflect real differences between endpoint and gender susceptibility. This must be regarded as a hypothesis-generating study.

TABLE 12.2.7

DOSE RESPONSE		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
(A1) There is no dose-response trend. On the contrary, the risk estimates for the medium-exposure group are usually higher than those for the high-exposure group	(F1) Theoretical data show that misclassification of exposure may increase risk estimate in intermediate exposure category (Dosemeci et al., 1990), (DelPizzo & Salzberg, 1992).	(C1) The pattern of the highest risk estimates appearing in the medium exposure group has been observed in many other occupational studies and has been attributed to misclassification. Nevertheless, the absence of a trend must affect the credibility of the data.

TABLE 12.2.8

COHERENCE/VISIBILITY		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
N.A.	N.A.	N.A.

TABLE 12.2.9

EXPERIMENTAL EVIDENCE		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
See "Generic Issues" chapter.		

TABLE 12.2.10

PLAUSIBILITY		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
See "Generic Issues" chapter.		

TABLE 12.2.11

ANALOGY		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
See "Generic Issues" chapter.		

TABLE 12.2.12

TEMPORALITY		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
See "Generic Issues" chapter.		

TABLE 12.2.13

SPECIFICITY AND ASSOCIATIONS WITH OTHER DISEASES		
AGAINST CAUSALITY	**FOR CAUSALITY**	**COMMENT AND SUMMARY**
See "Generic Issues" chapter.		

TABLE 12.2.14

SUMMARY TABLE FOR THE DISEASES CONSIDERED HERE			
	HOW LIKELY IS THIS PATTERN OF EVIDENCE UNDER:		
	THE "NO EFFECT" HYPOTHESIS	THE CAUSAL HYPOTHESIS	EFFECT ON CONFIDENCE
Chance.	Possible	Possible	No impact
Bias.	Possible	Possible	No impact
Confounding.	Possible	Possible	No impact
Combined chance, bias, confounding.	Possible	Possible	No Impact
Strength of association.	Possible	Possible	No impact
Consistency.	Very likely for women Unlikely for men	Unlikely for women Very likely for men	Lowers prior confidence that EMFs increase the risk of all cancers in women Increases our confidence substantially that EMFs increase the risk of many cancers in men
Coherence.	Possible	Possible	Decreases the confidence of EMF as a broadband cancer risk in women. Increases the confidence in EMF as a risk factor for many cancers in men.
Dose response.	Possible	Possible	No impact
Coherence/visibility.	Possible	Possible	No impact
Experimental evidence.	Unlikely	Possible	Increases confidence
Plausibility.	Possible	Possible	No impact
Analogy.	Possible	Possible	No impact
Temporality.	Possible	Possible	No impact
Specificity and associations with other Diseases.	Possible	Likely	No impact or slight increase

12.3 Posterior (Updated) Degree of Certainty and IARC Classification

12.3.1 Statements of Individual Reviewers

Reviewer 1 (DelPizzo)

All cancers

Degree of Certainty: After eliminating the cancers evaluated individually in this document, there are more risk estimates > 1 than < 1, but not enough to rule out chance as an explanation. Although Floderus's results raise interesting hypotheses to explore (see pro and con arguments above), they do not provide evidence that EMFs are a broadband cancer risk. For Reviewer 1 the evaluation is: "strongly believe that EMFs do not add to the risk" of all cancers. For the purpose of decision analysis, numerical values of 0 to 10 are defensible with a median estimate of 6 out of 100.

IARC Classification: "inadequate."

Reviewer 2 (Neutra)

Degree of Certainty: The pattern of associations does not suggest that all types of cancer are associated with EMF-related jobs. In women the number of cancers with associations above the null is about the same as the associations below the null. In men there are somewhat more cancers with associations above the null than expected, but not all cancers are elevated. This evidence has moved the degree of certainty to about 3 out of 100, with a range from 1 to 10. The evidence for the cancers that were above the null, other than those already discussed, is not extensive enough to move confidence above the prior confidence for those conditions.

IARC Classification: The animal, mechanistic and epidemiological evidence does not point towards EMFs as a universal carcinogen, so the evidence is "inadequate" to implicate EMFs in this way.

Reviewer 3 (Lee)

Degree of Certainty: The human evidence of the other cancers is based mainly on one study where very weak associations for surrogate occupational exposures, mostly among men, were found. Hence, Reviewer 3's prior for a weak relative risk is slightly increased by a weak positive-association pattern across studies and by the positive association found for childhood leukemia and adult brain cancer. However, this reviewer's prior is considerably decreased by the fact that the evidence is based on one study assessing multiple conditions. Hence, the posterior degree of certainty for purposes of the policy analysis falls within the "improbable that it is a cause" category. The range of uncertainty about the evidence using this reviewer's median prior is 4 to 7 with a median at 3.

IARC Classification: The human evidence is weak (based on one study) where chance, bias, and confounding cannot be ruled out. Also, the animal evidence is lacking and there is no sound mechanistic rationale. Given this, the evidence, as a whole, is sufficient for a classification of "not classifiable."

12.3.2 SUMMARY OF THE THREE REVIEWERS' CLASSIFICATIONS

CONDITION	REVIEWER	IARC CLASS	CERTAINTY PHRASE	DEGREE OF CERTAINTY IN CAUSALITY FOR POLICY ANALYSIS
				0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Do EMFs increase the risk of all cancers?	1	3	Strongly believe not	
	2	3	Strongly believe not	
	3	3	Strongly believe not	

12.4 QUESTIONS RELEVANT TO DOSE RESPONSE AND POLICY

TABLE 12.4.1

HOW CONFIDENT ARE THE REVIEWERS THAT SPECIFIC EXPOSURE METRIC OR ASPECT OTHER THAN 60 HZ TWA MAGNETIC FIELD IS ASSOCIATED WITH THIS DISEASE?	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
No evidentiary base.	None.

TABLE 12.4.2

EVIDENCE FOR THRESHOLD OR PLATEAU	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
No evidentiary base.	None.

TABLE 12.4.3

EVIDENCE FOR BIOLOGICAL WINDOWS OF VULNERABILITY	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
No evidentiary base.	None.

TABLE 12.4.4

CONSISTENT INDUCTION PERIOD OR REQUIRED DURATION OF EXPOSURE	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
No evidentiary base.	None.

TABLE 12.4.5

EMFs COMPARED TO OTHER RISK FACTORS FOR THIS DISEASE	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
No evidentiary base.	None.

TABLE 12.4.6

RELATIVE RISK COMPARED TO THAT WHICH WOULD GENERATE 1/1000 OR 1/100,000 THEORETICAL LIFETIME RISK	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
Not applicable.	Not applicable.

TABLE 12.4.7

EVIDENCE FOR RACIAL OR CLASS DIFFERENCES IN EXPOSURE OR VULNERABILITY	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
No evidentiary base.	None.

TABLE 12.4.8

ROOM FOR IMPROVEMENT IN QUALITY OR SIZE IN BEST EXISTING STUDIES	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
None, until present study is replicated.	None.

TABLE 12.4.9

NEW STUDIES IN PIPELINE	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
None.	None.

TABLE 12.4.10

CAPABILITY OF CHANGING ASSESSMENT	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
(C1) There are no similar studies in progress; therefore, it is not envisaged that this evaluation can be changed in the foreseeable future.	None.

TABLE 12.4.10

HOW LIKELY IS IT THAT FURTHER STUDIES COULD RESOLVE CONTROVERSIES?	
COMMENT AND SUMMARY	**IMPACT ON POLICY**
(C1) Very likely.	None for now.